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REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
Jan. 23, 1996

3. REPORT TYPE AND DATES COVERED
Final Progress Rep., 12/1/94-11/30/95

4. TITLE AND SUBTITLE
"Ultrafast studies of energetic material by shock waves using optical nanogauges: the first ten nanoseconds"

5. FUNDING NUMBERS
DAAH04-95-1-0045

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9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
ARO 33987.1-CH-RIP

11. SUPPLEMENTARY NOTES
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12a. DISTRIBUTION / AVAILABILITY STATEMENT
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12 b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This grant was awarded for the procurement of laser equipment. Various ultrashort lasers were evaluated and bids were outsourced. After competitive bidding and evaluation by the PI, a femtosecond Ti:sapphire laser system was purchased. It was delivered in June, 1995. Since that time, we have set up the laser and tested it with diagnostic equipment also purchased using the grant. An optical parametric amplifier system was designed and constructed. Preliminary results with this system are encouraging. We have been able to generate quite high power pulses in the mid-IR. An experimental set up was constructed. The laser will initially be used for studies of energy transfer in high explosives, and the roles of energy transfer rates in determining sensitivity, using the technique of two-dimensional vibrational spectroscopy.

19960209 097

14. SUBJECT TERMS
femtosecond laser; optical parametric amplifier, infrared spectroscopy, high explosives, molecular energy transfer

15. NUMBER IF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

Final progress report

"Ultrafast studies of energetic material initiation by shock waves using optical nanogauges: the first ten nanoseconds"

33987-CH-RIP; DAAH04-95-1-0045

Author: Dana D. Dlott

Statement of the problem and progress to date:

This grant was to fund the purchase of laser equipment to study the dynamics of energetic materials on a short time scale, with the intent of better understanding the relationships between dynamical behavior and energetic material sensitivity to shock initiation. Although the laser is a versatile instrument which can be used in several types of experiments, we decided to concentrate on the problem of measuring energy transfer rates in high explosives, using a two-dimensional vibrational spectroscopy technique. We have already used an older laser to study energy transfer in liquid nitromethane. However we have become acutely aware of the many drawbacks of this older laser, primarily in the areas of limited time resolution and poor signal to noise. We decided to purchase a Ti:sapphire laser system which was optimized for this experiment, the diagnostic equipment to monitor and verify its performance, and the optical instrumentation needed to generate the intense tunable mid-IR pulses needed to initiate energy transfer phenomena, and to monitor the energy transfer process using Raman spectroscopy.

The contract period began Dec. 1, 1994. At that time, all potential vendors were contacted, and a request for competitive bid quote (RFQ) was written. Eventually the bids were received. The lowest cost bid was from CMXR corporation. Dr. Dlott visited CMXR headquarters to see an operating laser and to talk to their engineers, and he became satisfied that their laser was going to meet his specifications. Dlott was extremely impressed by CMXR's technology and their people. Dlott's request was out of the ordinary in one respect. The nominal pulse duration for this type of laser is 100 fs. Dlott wanted a longer pulse duration of 500 fs because technical calculations convinced him that the narrower optical frequency bandwidth of the longer pulse was better for these experiments. CMXR engineers have invented a very nice system for tuning the pulse width out to larger values which seemed much better than schemes available from other vendors. The order was placed with CMXR.

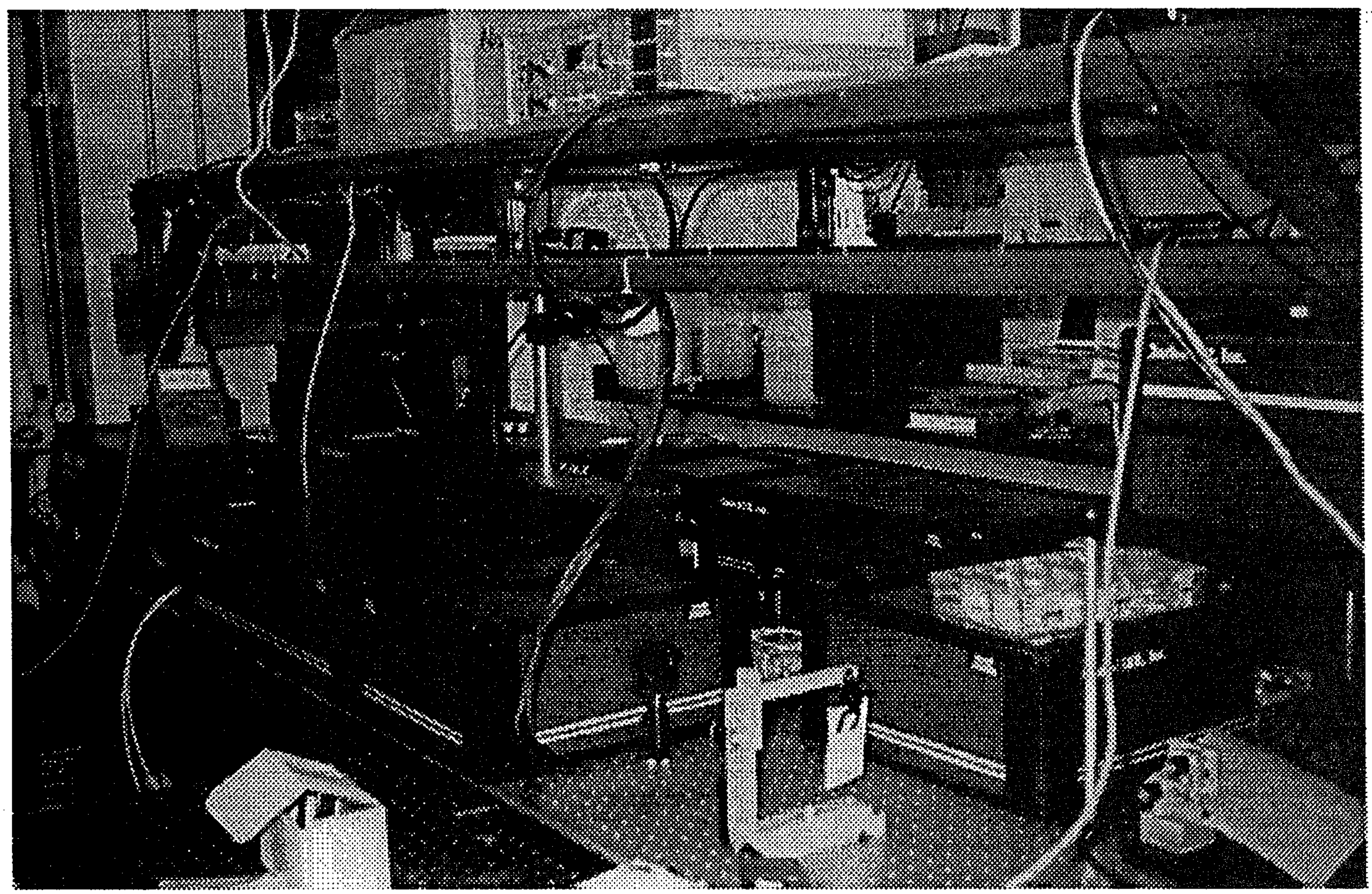
After seemingly endless months of paper pushing, including a vote by the Board of Trustees of the University of Illinois, the order was placed, and the laser was delivered in June, 1995. During this time, the laboratory was prepared for the laser, and the diagnostic equipment and other components for the experiment were ordered. A postdoctoral associate, Dr. John Deak, who had a lot of familiarity with this type of equipment, was hired.

The biggest technical problem was determining how best to generate the high power tunable mid-IR pulses needed for the measurements. There was nothing available at that time which would fill our need. Dlott and Deak together did a number of calculations and evaluations, and came up with a novel approach, which involves mixing the output of the laser with a longer optical pulse from a solid-state Nd:YAG laser, to produce mid-IR in a new material, KTA.

At the present time, we have the laser all set up and operating within specifications. We have built the entire experimental set up and the solid-state YAG laser is also operating well. We have succeeded in generating modest power mid-IR pulses using our scheme, but we still about a factor of ten below our target, which is to generate 50 μJ pulses at 3,000 cm^{-1}, resonant with the C-H stretching vibration of nitromethane. I think our progress is quite good, and we hope to be taking data in a couple of months.

Publications funded by this grant: none

Scientific personnel funded by this grant: none (equipment acquisition only)



Photograph of femtosecond laser system installed in Dlott lab at University of Illinois